METHOD FOR INSERTING LENGTH INDICATOR IN PROTOCOL DATA UNIT OF RADIO LINK CONTROL

BACKGROUND OF THE INVENTION

1. Field of the Invention

[1] The present invention relates to a radio link protocol, and more particularly to a method for inserting a Length Indicator (LI) in a Radio Link Control (RLC) that selectively controls LI value insertion so that any LI to be inserted in the next PDU may be prevented from being unnecessarily included.

2. Background of the Related Art

[2] The current trend in communications technology is concentrating research into allowing access of multimedia applications without restrictions on time/space and endeavors for visible achievement thereof. The development of digital data processing and transmission technology is consequently on the verge of realizing a real time global data communication system via satellites in which wire and radio communications are unified.

[3] Also, the development of digital data processing and transmission technology allows still and dynamic images to be transmitted in real time via a network, as well as allowing the previous voice communication and information to be accessed freely without discriminating between wire and radio communication at any time and

place. International Mobile Telecommunication-2000 (IMT-2000) will be an example thereof.

[4] The Radio Link Control (RLC) layer presented in the invention is the second layer of 3GPP, which has two kinds of Packet Data Units (PDUs). They are an Unacknowledged Mode Packet Data Unit (UMD PDU), used when the acknowledgment signal transmission to a sending side is not necessary after receiving the PDU in a receiving side, and an Acknowledged Mode PDU(AMD PDU). Each PDU format is as shown in Figure 1 and Figure 2, respectively.

[5] As shown in Figure 1, a format of the UMD PDU is composed of a header, a LI group, data, and a PAD (Padding). The header is composed of a 7 bit Sequence Number as a field for indicating the sequence number of each PDU, and a 1 bit Extension (E) field to indicate if the next field is data or LI and E bit. The data group is a field corresponding to the Service Data Units (SDUs) descended from an upper layer including at least one SDU. Since such a data group is variable in magnitude, a padding is carried out for octet aligning the overall PDU size.

[6] Here, the PDU is sourced from ITU-T X.200/ISO-IEC7498-1, and the SDU is sourced from ITU-T X.140.

[7] As shown in Figure 2, a format of the AMD PDU includes a header, a LI group, and data. In the AMD PDU, a piggyback type status PDU is inserted instead of the padding to enable the transmission.

[8] The header of the AMD PDU additionally has a 1 bit D/C field to indicate if the pertinent PDU is loaded with data information or control information, a P field as a 1 bit polling field for requesting a status report to the receiving side, and a 2 bit Header Extension (HE) field for notifying if the next data is data or LI and E bit.

[9] In the above UMD PDU and the AMD PDU, the LI group is composed of the LI and E bit, in which each of the LIs is a field for indicating the boundary of each SDU when the PDU includes several SDUs. Each LI indicates the number of octects from the first octect in the data group to the last octet of each SUD. The LI group means the LIs for the SDUs included in one PDU. The LI size is 7 bits or 15 bits.

[10] In the case of the AMD PDU, the 7 bit LI is used if the PDU size is at most 126 octets, and alternatively, the 15 bit LI is used. In the case of the UMD PDU, the 7 bit LI is used if the PDU size is at most 125 octets, and alternatively, the 15 bit LI is used.

[11] Some values of these LIs are predefined for use in specific purposes.

[12] Table 1 illustrates LI values for a specific purpose (in the case of the 7 bit LI), and Table 2 illustrates LI values for a specific purpose in the case of the 15 bit LI.

[13] As can be seen from Figure 1 and Figure 2, if the end of one SDU (referred to as A) correctly matches the end of the PDU, the first LI value of the very next PDU (referred to as B) is inserted as 'LI=0' to so indicate.

[14] In the case of the 15 bit long LI, if the last segment of the RLC SDU is one octet insufficient to the end of the PDU, the first LI of the very next PDU has the value

of '111 1111 1111 1011' to so indicate. Also, the PDU uses 'LI=1' as a value to indicate that the rest part of the RLC PDU is a padding, where the padding is necessarily positioned at the last of the RLC PDU.

Table 1

Length: 7bit

Bit	Description
0000000	The previous RLC PDU was exactly filled with the last segment of an RLC SDU.
1111100	Reserved
1111101	Reserved
1111110	AM PDU: The rest of the RLC PDU includes a piggybacked STATUS PDU. UM PDU: Reserved
1111111	The rest of the RLC PDU is padding.

Table 2

Length: 15bit

Bit	Description
000000000000000	The previous RLC PDU was exactly filled with the last segment of an RLC SDU.
111111111111011	The last segment of an RLC SDU was one octet short of exactly filling the last RLC PDU.
111111111111100	Reserved.
111111111111101	Reserved.
111111111111110	AM PDU: The rest of the RLC PDU includes a piggybacked STATUS PDU. UM PDU: Reserved.
111111111111111	The rest of the PDU is padding.

[15] Figure 3 illustrates the ends of the SDUs in one PDU by using the 7 bit LI in the AMD PDU. Here, the PDU size is 35 octets and the data size included in the PDU

is 24 octets.

[16] As can bee seen in Figure 3, the AMD PDU has three SDUs, for example SDU1, SDU2, and SDU3. Each of the SDUs has the size of 11 octets, 9 octets and 4 octets, respectively. The LI values for accumulatively indicating the octet numbers from the first octet to the last octet of each data part of SDU1, SDU2, and SDU3 are inserted as 11 (octet), 20 (octet) and 24 (octet), and more inserted with 'LI=111 1111' to express the rest part of the PDU is a padding (5 octet).

[17] In the related art, LI='0' is inserted into the very next PDU (B) in all the cases where the end of one SDU (A) exactly matches the end of the PDU in the RLC PDU.

[18] Figure 4, Figure 5, and Figure 6 illustrate three cases where LI='0' is inserted according to a method for inserting LI of the related art, in which Figure 4 shows a proper process, while Figure 5 and Figure 6 show problems of unnecessary LI value insertions.

[19] Referring first to Figure 4, LI='0' is attached to the next PDU. If the LI for the SDU2 in Figure 4 is included in the current PDU, one octet data of the SDU2 is necessarily shifted to the next PDU due to size of the LI. In other words, if a cumulative sum of LI=22 is recorded in the octect under LI=12 to indicate the end of SDU2, since the currently set PDU size is 25 octets and the sum octet of components of the PDU is 25, the sum octet of the PDU components becomes 26 and the end of the SDU2 does not match the end of the pertinent PDU. Then, it is meaningless to attach the second LI

(LI=22).

[20] Therefore in this case, LI='0' is inserted into the first LI of the next PDU (B) instead of inserting the second LI in the first PDU (A) to indicate the end of the SDU2.

[21] However, in the cases as illustrated in Figure 5 and Figure 6, the pertinent PDU (A) itself shows that the last SDU of the PDU (A) fits exactly into the PDU (A), including the various LIs, so that LI='0' need not be attached to the next PDU(B). Accordingly, the related art has various problems.

[22] For example, the LI='0' value indicating that the last segment of the very previous SDU exactly matches the end of the previous PDU is unnecessarily inserted to the very next PDU (B) even though the LI indicates the end of the SDU2 of the PDU(A) as shown in Figure 5.

[23] Also, the LI value or the LI='0' value is inserted to notify that the end of the pertinent PDU (A) (the middle PDU in Figure 6) is the padding since the end has one excessive octet (causing '0' padding as the position of the padding disappears due to the insertion of the final LI) as shown in Figure 6. Thus, inserting the LI='0' value in the very next PDU (B) is unnecessary since the LI='1' value means that the end of the pertinent PDU (A) correctly matches the last segment of the SDU2.

[24] In the dotted part under the SDU 2 of the pertinent PDU(A) of Figure 6, the PDU(A) size is 27 while the sum of the components of the PDU is 26 leaving 1 octet.

Therefore, the remaining one octet is padded as LI=1111111.

[25] The aforementioned problems are observed also in the UMD PDU as same as in the AMD PDU. Therefore, according to the method for inserting LI of the related art, the LI value or LI='0' value is unnecessarily inserted into the LI group of the PDU, which includes unnecessarily overlapped information thereby wasting network sources.

[26] The above references are incorporated by reference herein where appropriate for appropriate teachings of additional or alternative details, features and/or technical background.

SUMMARY OF THE INVENTION

[27] An object of the invention is to solve at least the above problems and/or disadvantages and to provide at least the advantages described hereinafter.

[28] It is an object of the present invention to provide a method of inserting a length indicator in a PDU that substantially obviates the problems and disadvantages of the related art.

[29] It is another object of the present invention to selectively apply the LI value insertion for indicating pertinent contents in generating PDUs in an RLC.

[30] It is another object of the present invention to indicate an end of the SDU when the very previous PDU (A) correctly matches the end of the previous PDU while preventing unnecessary insertion of an LI value.

[31] It is another object of the present invention to provide a length indicator that is selectively used when the boundary of a Service Data Unit (SDU) is within a Protocol Data Unit (PDU) where a PDU mode is used in a protocol structured Radio Link Control (RLC) layer for data transmission/receipt.

[32] It is another object of the present invention to provide a method for inserting a PDU LI in an RLC which is adapted to prevent unnecessarily inserting an LI value or LI='0' indicating that the last segment of the very previous SDU correctly matches the end of the very previous PDU even though there is an LI indicating the end of the SDU of the previous PDU or if an LI value or LI='1' is inputted for notifying a padding in which the end of the PDU has one excessive octet (in using a 7 bit LI) or two excessive octet (in using 15 bit LI).

[33] In order to achieve at least the above objects in whole or in parts, there is provided a method for inserting PDU LI in an RLC where an PDU is generated from the RLC, in which an LI value can be prevented from being unnecessarily inserted, by which when the end of the SDU in the very previous PDU(A) correctly matches the end of the very previous PDU, the LI value is inputted to the head of an LI group of the next PDU if the LI indicating the end of the very previous SDU cannot be inputted into the very previous PDU, an LI value (LI='0') is not inputted into an LI group of the very next PDU(B) if the previous PDU(A) has the LI indicating the end of the very previous SDU, and an LI value (LI='1') is not inputted into the LI group of the very next PDU(B) if the

end of the pertinent PDU(A) has one excessive octet in which the LI value (LI='1') is inputted to notify it as a padding. Consequently, the next PDU is free from unnecessary insertion of the LI value so that waste of network resources can be prevented and overhead required for processing unnecessary LI values also can be reduced.

[34] To further achieve at least these objects in whole or in parts, there is provided a method for inserting a Protocol Data Unit (PDU) Length Indicator (LI) in a Radio Link Control (RLC) where a PDU mode is used in a protocol structured RLC layer for data transmission/receipt, the improvement comprising a eliminating from a next PDU an information component indicating that a current PDU size corresponds to the total size of components of the PDU, if the current PDU size corresponds to the total size of components of the PDU and the current PDU has information indicating that the current PDU size corresponds to the total size of components of the PDU.

[35] To further achieve at least these objects in whole or in parts, there is provided a method for inserting a Protocol Data Unit (PDU) Length Indicator (LI) in a Radio Link Control (RLC) where a PDU mode is used in a protocol structured RLC layer for data transmission/receipt, comprising setting a size of a PDU to be used in a protocol structure and a total size of components of the PDU; determining if an information LI value for an end of a last SDU of the PDU can be indicated by using the set PDU size and inputting the LI value into the PDU if it is determined to be possible; and comparing the set PDU size with the total size of the PDU components.

[36] To further achieve at least these objects in whole or in parts, there is provided a method for inserting a Protocol Data Unit (PDU) Length Indicator (LI) in a Radio Link Control (RLC) where a PDU mode is used in a protocol structured RLC layer for data transmission/receipt, comprising forming a plurality of PDUs from a plurality of SDUs, each PDU having a header containing at least one length indicator representing a length of a corresponding SDU contained in the PDU or representing a sum of lengths of corresponding SDUs contained in the PDU, wherein a PDU contains a length indicator having a prescribed sequence of bit pattern when the previous PDU header did not contain complete length of the SDUs in the previous PDU; and wherein a PDU does not contain a length indicator that indicates the end of the SDU in the previous PDU if the previous PDU ends exactly with a last segment of the SDU.

[37] To further achieve at least these objects in whole or in parts, there is provided a method of forming a header of a PDU, comprising forming a first PDU from a plurality of SDUs; forming a header of the first PDU including a plurality of length indicators (LI), the length indicators representing lengths of corresponding SDUs of the PDU, wherein a final length indicator is provided to indicate that the PDU includes a final segment of padding, and wherein the final segment of padding can have a length of zero such that a subsequent second PDU header does not include information regarding the size of the first PDU.

[38] To further achieve at least these objects in whole or in parts, there is

provided a method for inserting a PDU Length Indicator indicating that a previous PDU ends at the end of a last SDU of the PDU in an RLC of a radio communication system where a PDU mode is used in a protocol structured RLC layer for data transmission, comprising detecting whether a previous PDU ends at the end of a last SDU of the PDU; checking whether a length indicator of the previous PDU indicates that the previous PDU ends at the end of the last SDU of the PDU; and inserting a PDU Length Indicator if the length indicator of previous PDU fails to indicate that the previous PDU ends at the end of last SDU of the PDU.

[39] To further achieve at least these objects in whole or in parts, there is provided a method for omitting a PDU Length Indicator indicating that previous PDU ends at the end of a last SDU of the previous PDU in an RLC of a radio communication system where a PDU mode is used in a protocol structured RLC layer for data transmission, comprising checking whether a length indicator of a previous PDU indicates that the previous PDU ends at an end of a last SDU of the previous PDU; and omitting the PDU Length Indicator if the length indicator of the previous PDU indicates that the previous PDU ends at the end of last SDU of the previous PDU.

[40] Additional advantages, objects, and features of the invention will be set forth in part in the description which follows and in part will become apparent to those having ordinary skill in the art upon examination of the following or may be learned from practice of the invention. The objects and advantages of the invention may be realized

and attained as particularly pointed out in the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[41] The invention will be described in detail with reference to the following drawings in which like reference numerals refer to like elements wherein:

[42] Figure 1 shows a format of an UMD PDU;

[43] Figure 2 shows a format of an AMD PDU;

[44] Figure 3 shows the ends of SDUs in one PDU by using a 7 bit LI in the AMD PDU;

[45] Figure 4 illustrates an example in which an LI='0' value is necessary in the next PDU in the AMD PDU;

[46] Figure 5 illustrates an example in which an unnecessary LI is inserted according to a method for inserting LI of the related art;

[47] Figure 6 illustrates another example in which an unnecessary LI is inserted according to a method for inserting LI of the related art; and

[48] Figure 7 is a flow chart for showing a method for inserting LI of a PDU in an RLC of the preferred embodiment of the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[49] Referring to Figure 7, the size of the PDU to be used in the PDU mode in

the protocol structured RLC layer for data transmission/receipt and components of the PDU and the size thereof are first set, as shown in step 70. The size, such as sequence number of the components of the PDU, is a fixed value and the SDU has a variable size.

[50] After step 70, it is determined if the end of SDU i can be included in the current PDU (A), as shown in step 71. If it is determined not to be possible in step 71, a segment of SDU i is inserted according to the PDU size, as shown in step 72 .

[51] If, however, it is determined to be possible in step 71, it is determined whether the LI value for the last position of a random number of SDU i can be indicated with the current PDU (A) size in step 73.

[52] If the last SDU size cannot be indicated with the current PDU (A) size as a result of the determination in step 73, LI=000 0000 for indicating that the last segment of the very previous SDU correctly matches the end of the very previous PDU (A) is recorded as the LI value first sequence of the next PDU (B), and the next PDU (B) is transmitted as in Figure 4, as shown in step 74.

[53] If the last SDU size can be indicated with the current PDU (A) size as a result of judging in step 73, the LI value of the last position of SDU i is indicated in the current PDU (A) in step 75.

[54] Then, it is determined if the current PDU (A) size matches the sum of the component size of the PDU (A) in step 76. In other words, if SDU i can be included in the pertinent PDU even after the LI value about the last position of SDU i is inserted as

a result of judging in step 73, the process proceeds to step 75 to insert the LI value for the last position of SDU i and to determine if the PDU size is the same as the sum of the data up to the present and the LI group and header size.

[55] As a result of the determination in step 76, if the current PDU (A) size is the same as the sum of the data up to the present and the LI group and header size, inserting LI='0' to the next PDU (B) is not necessary. Consequently, the next PDU(B) is transmitted without including LI=0, which indicates that the current PDU(A) size matches the end of SDU i in step 77.

[56] If, however, the current PDU (A) size is the same as the sum of the data up to the present and the LI group and header size as a result of judging in step 76, the next PDU (B) is transmitted including LI=0, which indicates that the current PDU (A) size matches the end of SDU i, even though inserting LI='0' into the next PDU (B) is not necessary in the related art.

[57] In other words, referring Figure 5, LI=000 0000 for indicating that the last segment of the very previous SDU correctly matches the end of the very previous PDU(A) is unnecessarily transmitted as part of the next PDU(B), even though the previous PDU(A) has the LI for indicating the last of SDU 2.

[58] Meanwhile, if the current PDU (A) size is not the same as the sum of the data up to the present and the LI group and header size as a result of the determination in step 76, it is determined whether there is any more SDU to be transmitted in step 78.

If there is more SDU to be transmitted, the process proceeds to step 80, where the i value is increased as much as +1 to repeat from step 71 for the SDU in the next sequence.

[59] However, if there is no SDU to be transmitted, the process proceeds to step 79 where the LI='1' value (which means that the rest part of the PDU is a padding) is inputted and a padding is inputted in the rest part of the pertinent PDU. In other words, the next PDU (B) is transmitted without having the LI='0' value or information indicating that the last segment of the very previous SDU correctly matches the end of the very previous PDU (A), which is additionally inputted to the head of the LI group of the next PDU (B).

[60] In the related as shown in Figure 6, LI=000 0000, which indicates that the last segment of the very previous SDU correctly matches the end of the very previous PDU (A), is unnecessarily transmitted as inputted into the next PDU(B) even though the PDU size becomes the same as the total size of the components of the PDU as LI=111 1111 for indicating the padding when the end of the pertinent PDU (A) is excessive with one octet is inputted into the LI group and thus the padding position becomes zero.

[61] Table 3 illustrates LI values for a specific purpose in the case of the 7 bit LI, and Table 4 illustrates LI values for a specific purpose in the case of the 15 bit LI, both of which are revised according to the preferred embodiment.

[62] Thus, if the end of one SDU correctly matches the end of the PDU, the first LI value of the very next PDU is inserted as 'LI=0' to so indicate.

[63] In the case of the 15 bit long LI, if the last segment of the RLC SDU is one

octet insufficient to the end of the PDU, the first LI of the very next PDU has the value of '111 1111 1111 1011' to so indicate. Also, the PDU uses 'LI=1' as a value to indicate that the rest part of the RLC PDU is a padding, where the padding is necessarily positioned at the last of the RLC PDU.

Table 3

Length: 7bit

Bit	Description
0000000	The previous RLC PDU was exactly filled with the last segment of an RLC SDU and there is no LI that indicates the end of the SDU in the previous RLC PDU.
1111100	Reserved (PDUs with this coding will be discarded by this version of the protocol).
1111101	Reserved (PDUs with this coding will be discarded by this version of the protocol).
1111110	AM PDU: The rest of the RLC PDU includes a piggybacked STATUS PDU. UM PDU: Reserved (PDUs with this coding will be discarded by this version of the protocol).
1111111	The rest of the RLC PDU is padding. The padding length can be zero.

Table 4

Length: 15bit

Bit	Description
000000000000000	The previous RLC PDU was exactly filled with the last segment of an RLC SDU and there is no LI that indicates the end of the SDU in the previous RLC PDU.
111111111111011	The last segment of an RLC SDU was one octet short of exactly filling the last RLC PDU.
111111111111100	Reserved (PDUs with this coding will be discarded by this version of the protocol).
111111111111101	Reserved (PDUs with this coding will be discarded by this version of the protocol).

111111111111110	AM PDU: The rest of the RLC PDU includes a piggybacked STATUS PDU. UM PDU: Reserved (PDUs with this coding will be discarded by this version of the protocol).
111111111111111	The rest of the PDU is padding. The padding length can be zero.

[64] The present invention as described with reference to the preferred embodiment has many advantages. For example, if a current PDU size corresponds to the total size of components of the PDU and the current PDU has information indicating that the current PDU size corresponds to the total size of components of the PDU, a component of the next PDU does not include information indicating that the current PDU size corresponds to the total size of components of the PDU. Therefore, the next PDU is free from unnecessary insertion of the LI value so that waste of network resources can be prevented and overhead required for processing unnecessary LI values also can be reduced.

[65] The foregoing embodiments and advantages are merely exemplary and are not to be construed as limiting the present invention. The present teaching can be readily applied to other types of apparatuses. The description of the present invention is intended to be illustrative, and not to limit the scope of the claims. Many alternatives, modifications, and variations will be apparent to those skilled in the art. In the claims, means-plus-function clauses are intended to cover the structures described herein as performing the recited function and not only structural equivalents but also equivalent

structures.